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(71) Applicant: **Icopal A/S**
2730 Herlev (DK)

(72) Inventor: **Jensen, Eirik Sandberg**
4000 Roskilde (DK)

(74) Representative: **Plougmann & Vingtoft A/S**
Sundkrogsgade 9
P.O. Box 831
2100 Copenhagen O (DK)

(54) **A vapour barrier or underroof for buildings**

(57) A film or foil of ethylene vinyl alcohol with a thickness of between 5 µm and 50 µm is used as a water vapour barrier or underroof (15) for buildings. At least parts of the opposite side surfaces of the film or foil are exposed to moisture of the ambient atmosphere. It is important that the vapour diffusion resistance of a vapour barrier is as low as possible under humid conditions and as high as possible under dry conditions. A film of ethylene vinyl alcohol has a very wide diffusion resistance range and provides a more durable vapour barrier or underroof as the material has excellent weather ability. Preferably, the film or foil of ethylene vinyl alcohol has a thickness of between 5 µm and 50 µm.

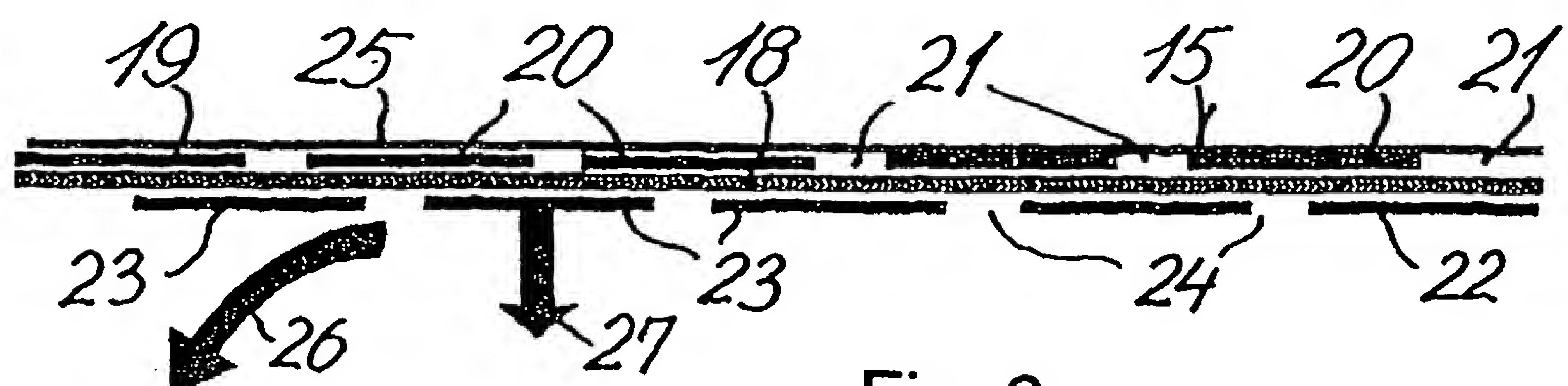

Fig. 2

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to vapour barriers or underroofs for buildings. Such vapour barriers are known e.g. from JP 1 146 050, EP 0 821 755 and WO 00/37751.

[0002] Thus, JP 1 146 050 discloses a waterproof under-sheet obtained by laminating synthetic resin film on a surface of asphalt, rubber or a resin sheet reinforced with a fibrous sheet. The waterproof sheet is not affected by the weather conditions.

[0003] The vapour barrier disclosed in EP 0 821 755 comprises a sheet material whose resistance to water vapour diffusion depends on the ambient humidity, and wherein the resistance (S_d) is 2-5 m diffusion-equivalent air-layer thickness when the a relative humidity is 30-50% and less than 1 m diffusion-equivalent air-layer thickness when the relative humidity is 60-80%.

[0004] WO 00/37751 discloses a vapour barrier with two membranes, namely a substantially water impervious membrane and a membrane that has a water vapour diffusion resistance that varies depending on the relative humidity.

[0005] In order to obtain the best possible water vapour transport during the various seasons of a year, it is desirable that a vapour barrier or underroof for use in a building or building structure spans over a water-vapour-diffusion-resistance range being as large as possible. In the summer time, when the ambient relative humidity is high, the barrier must show as low diffusion resistance as possible, and in the winter time, when the ambient relative humidity is low, the diffusion resistance must be as high as possible. Thus, a vapour barrier having a membrane with a diffusion resistance that varies in dependency of the relative humidity of air in contact therewith is preferred.

[0006] Several known vapour barriers comprise a membrane having a diffusion resistance that varies in dependency of the relative humidity of air in contact therewith. However, the ratio between the resistance in the humid condition and the resistance in the dry condition of these membranes is typically maximum 1:5. In the known vapour barriers, the diffusion resistance in the humid condition is usually equivalent to less than 1 m air column and up to 5 m air column in the dry condition.

DESCRIPTION OF THE INVENTION

[0007] The present invention provides a vapour barrier or an underroof for buildings, which is much more efficient than known underroofs, the barrier or underroof having a vapour diffusion resistance that varies in dependency of the relative humidity over a wide range.

[0008] According to preferred embodiments of the present invention a film or foil of ethylene vinyl alcohol (EVOH) having a thickness of between 5 μm and 50 μm is used as a water vapour barrier or an underroof for buildings. Preferably at least parts of the opposite side surfaces are exposed to the atmosphere outside and inside the building, respectively. It has been found that such a film or foil is an excellent vapour barrier having a vapour diffusion resistance, which in humid condition (60-100%) is equivalent to less than 1 m air column and in a dry condition (20-50%) is equivalent to at least 8 m air column.

[0009] Preferably, the thickness of the film is between 10 μm and 40 μm, such as between 15 μm and 30 μm, preferably between 20 μm and 25 μm.

[0010] It is crucial that the vapour diffusion resistance of the vapour barrier or underroof varies in dependency of the relative humidity of air in contact therewith, namely such that the resistance is as low as possible under humid conditions and as high as possible under dry conditions. The invention provides a vapour barrier or underroof having a very wide diffusion resistance span in relation to known underroofs. It has been found that a film of ethylene vinyl alcohol comprising between 25% and 40% ethylene has a vapour diffusion resistance ranging from equivalent to at least 8 m air column at a relative humidity of 20-50% and equivalent to less than 0.5 m air column at a relative humidity of 60-100% of air in contact with the membrane. In particular, the vapour diffusion resistance of such film is substantially equivalent to 10 m air column at an average relative humidity of 27% and substantially equivalent to 0.15 m air column at an average relative humidity of 73% of air in contact with the film, when the film comprises 27% ethylene and has a thickness of 22 μm.

[0011] Furthermore, the use of a ethylene vinyl alcohol film provides a more durable vapour barrier or underroof, as the material has an excellent weather ability compared to known materials used in vapour barriers or underroofs. When exposed to outdoor conditions, the polymer retains its colour, and it does not yellow or become opaque.

[0012] The film or foil of ethylene vinyl alcohol may be part of a laminate. Thus, at least one of the opposite side surfaces of the film of ethylene vinyl alcohol may have a water vapour penetrable film or foil laminated thereon. This water vapour penetrable film may be made from another hygroscopic material, such as Nylon, or, alternatively, the vapour penetrable film or foil may be a perforated film or foil of a substantially water vapour impervious material. The total area of the perforations preferably depends i.a. on the thickness of the film or foil of ethylene vinyl alcohol. Thus, the total area of the perforations is 0.5-20%, preferably 5-15%, of the total area of the film or foil of water vapour impervious material. In such case, the thickness of the film of ethylene vinyl alcohol is preferably between 0.5 μm and 25 μm.

[0013] Films or foils of ethylene vinyl alcohol has previously been used as packaging material in food, medical, pharmaceutical, cosmetic, agricultural and indus-

trial applications due to its eminent process ability and outstanding barrier properties.

[0014] In the use according to the invention the ethylene vinyl alcohol of the film may comprise 27% or 32% ethylene. The water vapour diffusion resistance of the film may be equivalent to at least 8 m air column at a relative humidity of 20-50% and less than 0.5 m air column at a relative humidity of 60-100% of air in contact with the membrane. The water vapour diffusion resistance of the film is substantially equivalent to 10 m air column at an average relative humidity of 27% and substantially equivalent to 0.15 m air column at an average relative humidity of 73% of air in contact with the film. At least one of the opposite side surfaces of the film of ethylene vinyl alcohol may have a water vapour penetrable film or foil laminated thereon. The water vapour penetrable film may be made from another hygroscopic material, such as Nylon. The vapour penetrable film or foil may be a perforated film or foil of a substantially water vapour impervious material. The total area of the perforations may be 0.5-100%, such as 0.5-20%, preferably 5-15%, of the total area of the film or foil of water vapour impervious material and the thickness of the film of ethylene vinyl alcohol may be between 0,5 μm and 25 μm.

[0015] According to a second aspect, the present invention relates to a water vapour barrier comprising a first water impervious membrane including a film or foil of ethylene vinyl alcohol, said film having a thickness of between 5 μm and 50 μm, preferably between 10 μm and 40 μm, such as between 15 μm and 30 μm, such as between 20 μm and 25 μm. At least parts of the opposite surfaces of the vapour barrier are preferably exposed to the moisture of the ambient atmosphere.

[0016] One or both sides of the ethylene vinyl alcohol film or foil may be covered by another water vapour penetrable film or foil, such as Nylon, or a perforated film or foil of a substantially water vapour impervious material.

[0017] The ethylene vinyl alcohol of the film may comprise between 25% and 40% ethylene, such as 27% or 32% ethylene.

[0018] Preferably, the material composition and thickness of the film is chosen so as to obtain a water vapour diffusion resistance of the film that is equivalent to at least 8 m air column at a relative humidity of 20-50% and less than 0.5 m air column at a relative humidity of 60-100% of air in contact with the film.

[0019] More preferred, the water vapour diffusion resistance of the film is substantially equivalent to 10 m air column at an average relative humidity of 27% and substantially equivalent to 0.15 m air column at an average relative humidity of 73% of air in contact with the film.

[0020] The vapour diffusion resistance may be higher such as equivalent to 15 m or 20 m air column at a relative humidity of 20-50% of air in contact with the film.

[0021] The vapour barrier may further comprise a second water impervious membrane of a water vapour penetrable film or foil covering at least one of the opposite side surfaces of the first membrane. This water vapour penetrable film forming the second membrane may be made from another hygroscopic material, such as Nylon, or may be made of a perforated film or foil of a substantially water vapour impervious material. Furthermore, a water absorbing material may be arranged within one or more spaces being defined between the first and second membrane.

[0022] In the barrier according to the invention, the second membrane may have a total area of perforations, which is 0.5-100%, such as 0.5-20%, preferably 5-15%, of the total area of the second membrane. Furthermore, a plurality of first through openings may be formed in the first membrane, and each of the spaces being defined between the first and second membrane may interconnect at least some of the first and second openings. The second through openings may be offset in relation to the first through openings. The first and second membrane may be connected to opposite sides of said water absorbing material, which may be in the form of an intermediate layer. The intermediate layer of water absorbing material may be a fibrous plastic material comprising fibres having a hydrophobic fibre core. The water vapour diffusion resistance of the first membrane may be equivalent to 10-100 m air column at any relative humidity of air in contact therewith. The barrier may further comprise a moisture distributing outer layer of water absorbing material, which may be connected to the outer surface of the first and/or second membrane. The outer layer of water absorbing material may be a fibrous, felt-like material. The first membrane may be formed by mutually parallel, transversely spaced first bands, the first through openings being defined between adjacent first bands. The second membrane may be formed by mutually parallel, transversely spaced second bands, the second through openings being defined between adjacent second bands. Each of the first bands may have a width exceeding the width of a corresponding space between adjacent second bands and may overlap the space and adjacent rim portions of the adjacent second bands. The maximum transverse overlap of the rim portions of the adjacent first bands may be 100 mm. The barrier may be in the form of a web-like material, the parallel, band-shaped openings extending in the longitudinal direction of the web-like material. The second membrane may be made from one or more of the materials selected from the group consisting of aluminium and other metals, polyethylene, polypropylene, polyethylene terephthalate, metallised polyethylene terephthalate, and polyvinylidene chloride.

[0023] According to a third aspect, the present invention relates to a laminate for use as underroofing and comprising a film or foil of ethylene vinyl alcohol forming a first water impervious membrane, said film having a thickness of between 5 μm and 50 μm, such as between 10 μm and 40 μm, such as between 15 μm and 30 μm, such as between 20 μm and 25 μm. At least parts of the

opposite surfaces of the laminate may be exposed to the moisture of the ambient atmosphere.

[0024] Preferably, the ethylene vinyl alcohol of the film comprises between 25% and 40% ethylene, such as 27% or 32% ethylene.

[0025] The water vapour diffusion resistance of the film is preferably equivalent to at least 8 m air column at a relative humidity of 20-50% and less than 0.5 m air column at a relative humidity of 60-100% of air in contact with the film.

[0026] More preferred, the water vapour diffusion resistance of the film is substantially equivalent to 10 m air column at an average relative humidity of 27% and substantially equivalent to 0.15 m air column at an average relative humidity of 73% of air in contact with the film.

[0027] The laminate may comprise,

- an outer layer formed by a perforated first film or foil, and
- an inner layer having at least some areas formed by said film of ethylene vinyl alcohol and, wherein the water vapour diffusion resistance of said first film substantially exceeds the maximum water vapour resistance of said film of ethylene vinyl alcohol. The diffusion resistance of the outer layer may in a non-perforated condition exceed 20 m and preferably 90 m air column.

[0028] In preferred embodiments of the present invention the perforation of the outer layer is within the range of 0.5 to 100%, preferably within the range of 0.5-20%. Furthermore, in preferred embodiments of the present invention the first film or foil of the outer layer is made from one or more of the following materials: aluminium and other metals, polyethylene, polypropylene, polyethylene terephthalate, metallised polyethylene terephthalate, and polyvinylidene chloride having a thickness of between 5-300 μm, preferably between 20-150 μm.

[0029] The laminate may comprise,

- a second water impervious membrane of a water vapour penetrable film or foil, and
- a first membrane having at least some areas formed by the ethylene vinyl alcohol film, the second water impervious membrane of a water vapour penetrable film or foil covering at least one of the opposite side surfaces of the first membrane.

[0030] The water vapour penetrable film forming the second membrane may be made from another hygroscopic material, such as Nylon. The second membrane may be a perforated film or foil of a substantially water vapour impervious material. The water vapour diffusion resistance of the second membrane may substantially exceed the maximum water vapour resistance of the ethylene vinyl alcohol film. The diffusion resistance of the outer layer may in a non-perforated condition exceed 20 m and preferably 90 m air column. The second membrane may be substantially impermeable to liquid water, but permeable to water vapour.

[0031] In preferred embodiments of the present invention the perforation of the second membrane is within the range of 0.5 to 100%, preferably within the range of 0.5-20%. Furthermore, in preferred embodiments of the present invention the second membrane may be made from one or more of the following materials: aluminium and other metals, polyethylene, polypropylene, polyethylene terephthalate, metallised polyethylene terephthalate, and polyvinylidene chloride having a thickness of between 5-300 μm, preferably between 20-150 μm.

[0032] The perforations of the second membrane may be concentrated in certain mutually spaced areas. The cross-sectional area of at least some of the perforations of the second membrane may be increasing from the outer surface of the film or foil towards the inner surface thereof. The minimum dimension or diameter of each of at least the majority of the perforations of the second membrane may be smaller than 1.5 mm. The second membrane may be made from one or more of the materials selected from the group consisting of aluminium and other metals, polyethylene, polypropylene, polyethylene terephthalate, metallised polyethylene terephthalate, and polyvinylidene chloride. The water vapour diffusion resistance may be equivalent to less than 10 m air column at a relative humidity of 60-100% of the air in contact with the film, the second membrane being made of perforated polyethylene. The laminate may further comprise an intermediate layer of a water vapour transmitting material, such as felt.

[0033] It has been found that the resistance of a laminate comprising a 7% perforated Polyethylene film having a thickness of 60 μm and a film of ethylene vinyl alcohol comprising 27% ethylene and having a thickness of 22 μm is equivalent to 4.5 m air column with a relative humidity of 95% at the ethylene vinyl alcohol film side of the laminate and a relative humidity of 50% at the Polyethylene film side of the laminate. If turned around having the ethylene vinyl alcohol film side of the laminate towards the less humid air the resistance of the laminate is equivalent to 9 m air column.

[0034] If the thickness of the ethylene vinyl alcohol film is reduced to 11 μm the resistance is equivalent 2.3 m air column with a relative humidity of 95% at the ethylene vinyl alcohol film side of the laminate and a relative humidity of 50% at the Polyethylene film side of the laminate. If turned around having the ethylene vinyl alcohol film side of the laminate towards the less humid air the resistance of the laminate is equivalent to 4.5 m air column.

[0035] Furthermore, it has been found that the resistance of a laminate comprising a 50% perforated Polyethylene film having a thickness of 60 μm and a film of ethylene vinyl alcohol comprising 27% ethylene and

having a thickness of 22 µm is equivalent to 0.7 m air column with a relative humidity of 95% at the ethylene vinyl alcohol film side of the laminate and a relative humidity of 50% at the Polyethylene film side of the laminate. If turned around having the ethylene vinyl alcohol film side of the laminate towards the less humid air the resistance of the laminate is equivalent to 1.5 m air column.

[0036] The resistance of a non-perforated Polyethylene film having a thickness of 60 µm is equivalent to 36 m air column, and the resistance of a film of ethylene vinyl alcohol comprising 27% ethylene and having a thickness of 22 µm is equivalent to 0.4 m air column with a relative humidity of 95% at one side and 50% at the other side thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The invention will be described in details below with reference to the accompanying drawings, wherein

Fig. 1 shows a roof structure including a water vapour barrier according to the invention,

Fig. 2 is a diagrammatic sectional view of a water vapour barrier according to the invention,

Fig. 3 is a sectional view of an embodiment of the laminate according to the invention, and

Fig. 4 is a sectional view of a second embodiment of the laminate according to the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

[0038] Fig. 1 shows a roof structure comprising a wooden frame including rafters 10 and a layer of boards 11, which are fastened to the upper sides of the rafters 10. The spaces defined between the rafters 10 and by the layer of boards 11 are filled with a heat insulating material, such as mineral wool 12. The layer of boards 11 is covered by an outer layer of roofing felt 13 and by a water tight film or foil 14 arranged between the roofing felt and the boards 11. The inner side of the heat insulating material or mineral wool 12 is covered by a water vapour barrier 15 according to the invention, and the inner side of the vapour barrier is covered by lining plates, such as plasterboards 16 which are fastened to laths 17.

[0039] Fig. 2 illustrates an embodiment 15 of a water vapour barrier according to the invention more in detail. The water vapour barrier 15 comprises an intermediate thin layer 18 of a water absorbent material, such as a fibrous material, which may be a mixture of polypropylene fibres and acrylic fibres. The thickness of the layer 18 may, for example, be 0.5-1 mm. A first membrane 19 of a polyethylene film is fastened to the upper surface of the intermediate fibrous layer 18. The first membrane 19 is formed by a number of mutually parallel bands 20 of a polyethylene film. The bands or strips 20 are mutually transversely spaced so as to form band-like or strip-like openings 21 therebetween. A second membrane 22 is applied to the lower surface of the intermediate layer 18, for example by means of a polymer glue. The second membrane 22 is also formed by a number of parallel bands or strips 23 of plastic film. Each of these bands or strips is positioned opposite to one of the openings 21, so as to overlap not only this opening, but also adjacent rim portions of the bands 20. At least some of the bands or strips 23 are made from an ethylene vinyl alcohol having a water vapour diffusion resistance which is dependent on the relative humidity of the air being in contact therewith.

[0040] Free water, which comes into contact with the outer water absorbing layer 25, will be distributed along the upper surface of the first membrane 19 and passed to the openings 21 in the first membrane where the water may come into contact with and be absorbed by the intermediate layer 18. As indicated by an arrow 26 the water may be passed to the opening 24 in the second membrane 22 by draining or capillary effect. Furthermore, as long as the relative humidity of air within the roof structure and consequently at the openings 21 in the first membrane 19 is higher than in the room defined by the plasterboards 16, water vapour also diffuses through the second membrane 22 as indicated by an arrow 27.

[0041] Fig. 3 is a cross-sectional view of a laminate 28 for an underroof. This laminate 28 comprises an upper or outer layer 29, which may be in the form of a perforated plastic film or a metal foil, a lower or an inner layer 30 of ethylene vinyl alcohol, and an intermediate layer 31 of a porous, felt-like material.

[0042] Fig. 4 is a cross-sectional view of a laminate 28' for an underroof. This laminate 28' comprises an upper or outer layer 29, which may be in the form of a perforated plastic film or a metal foil and a lower or an inner layer 30 of ethylene vinyl alcohol.

[0043] In the preferred embodiments shown in the figures, the ethylene vinyl alcohol comprises 27% ethylene and has a thickness of 22 µm, the material thus having a diffusion resistance substantially equivalent to 0.16 m air column at an average humidity of 73%, and substantially equivalent to 10 m air column at an average humidity of 27%.

[0044] A film of ethylene vinyl alcohol comprising 32% ethylene and having a thickness of 20 µm has been tested and compared with a film of polyamide having a thickness of 80 µm. The test comprised a QUV-test (the material is alternately exposed to ultraviolet radiation, moisture and heat). The result showed that the polyamide film became brittle and cracked after 200 hours test, while the ethylene vinyl alcohol film after 600 hours test was undamaged. Thus, the ethylene vinyl alcohol film proved to be more durable.

Claims

1. Use of ethylene vinyl alcohol in the form of a film or foil having a thickness of between 5 µm and 50 µm as a water vapour barrier or underroof for buildings, at least parts of the opposite side surfaces of the film or foil being exposed to moisture of the ambient atmosphere.

2. Use according to claim 1, wherein the ethylene vinyl alcohol of the film comprises between 25% and 40% ethylene.

3. Use according to claim 1 or 2, wherein the water vapour diffusion resistance of the film is equivalent to at least 8 m air column at a relative humidity of 20-50% and less than 0.5 m air column at a relative humidity of 60-100% of air in contact with the membrane.

4. Use according to any of the claims 1-3, wherein at least one of the opposite side surfaces of the film of ethylene vinyl alcohol has a water vapour penetrable film or foil laminated thereon.

5. Use according to claim 4, wherein the vapour penetrable film or foil is a perforated film or foil of a substantially water vapour impervious material.

6. A water vapour barrier for buildings and comprising a first water impervious membrane including a film or foil of ethylene vinyl alcohol, said film having a thickness of between 5 µm and 50 µm, at least parts of the opposite side surfaces of the film or foil being exposed to moisture of the ambient atmosphere.

7. A barrier according to claim 6, wherein the ethylene vinyl alcohol of the film comprises between 25% and 40% ethylene.

8. A barrier according to claim 6 or 7, further comprising a second water impervious membrane of a water vapour penetrable film or foil covering at least one of the opposite side surfaces of the first membrane.

9. A barrier according to claim 8, wherein the second membrane is a perforated film or foil of a substantially water vapour impervious material.

10. A barrier according to claim 8 or 9, further comprising water absorbing material arranged within one or more spaces being defined between said first and second membranes.

11. A barrier according to claim 10, wherein a plurality of first through openings are formed in said first membrane, and wherein each of said spaces interconnects at least some of said first and second openings.

12. A barrier according to any of claims 6-11, further comprising a moisture distributing outer layer of water absorbing material, which is connected to the outer surface of said first and/or second membrane.

13. A barrier according to any of claims 10-12, wherein the first membrane is formed by mutually parallel, transversely spaced first bands, the first through openings being defined between adjacent first bands.

14. A barrier according to any of claims 8-13, wherein the second membrane is formed by mutually parallel, transversely spaced second bands, the second through openings being defined between adjacent second bands.

15. A barrier according to claim 14, wherein each of said first bands has a width exceeding the width of a corresponding space between adjacent second bands and overlaps said space and adjacent rim portions of said adjacent second bands.

16. A barrier according to any of the claims 8-15, wherein said second membrane is made from one or more of the materials selected from the group consisting of aluminium and other metals, polyethylene, polypropylene, polyethylene terephthalate, metallised polyethylene terephthalate, and polyvinylidene chloride.

17. A laminate for use as underroofing for buildings and comprising a film or foil of ethylene vinyl alcohol forming a first water impervious membrane, said film having a thickness of between 5 µm and 50 µm, at least parts of the opposite side surfaces of the film or foil being exposed to moisture of the ambient atmosphere.

18. A laminate according to claim 17, wherein the ethylene vinyl alcohol of the film comprises between 25% and 40% ethylene.

19. A laminate according to claim 17 or 18, further comprising a second water impervious membrane of a water vapour penetrable film or foil covering at least one of the opposite side surfaces of the first membrane.

20. A laminate according to claim 19, wherein the second membrane is a perforated film or foil of a substantially water vapour impervious material.

21. A laminate according to claim 20, wherein the cross-sectional area of at least some of the perfo-

rations of the second membrane is increasing from the outer surface of the film or foil towards the inner surface thereof.

22. A laminate according to claim 20 or 21, wherein the minimum dimension or diameter of each of at least the majority of the perforations of the second membrane is smaller than 1.5 mm.

23. A laminate according to any of the claims 17-22, wherein the second membrane is made from one or more of the materials selected from the group consisting of aluminium and other metals, polyethylene, polypropylene, polyethylene terephthalate, metallised polyethylene terephthalate, and polyvinylidene chloride.

24. A laminate according to any of the claims 20-23, further comprising an intermediate layer of a water vapour transmitting material, such as felt.

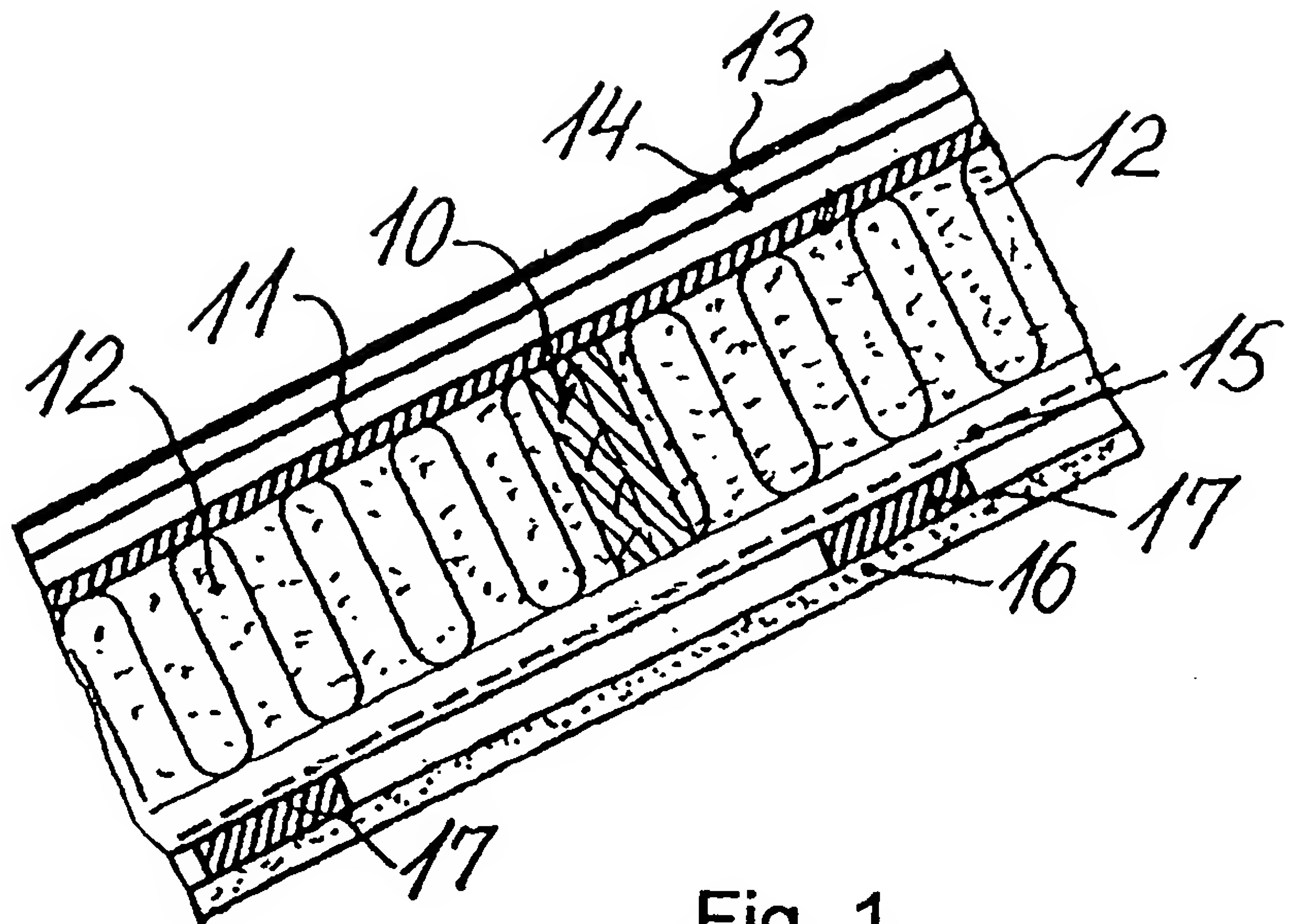

Fig. 1

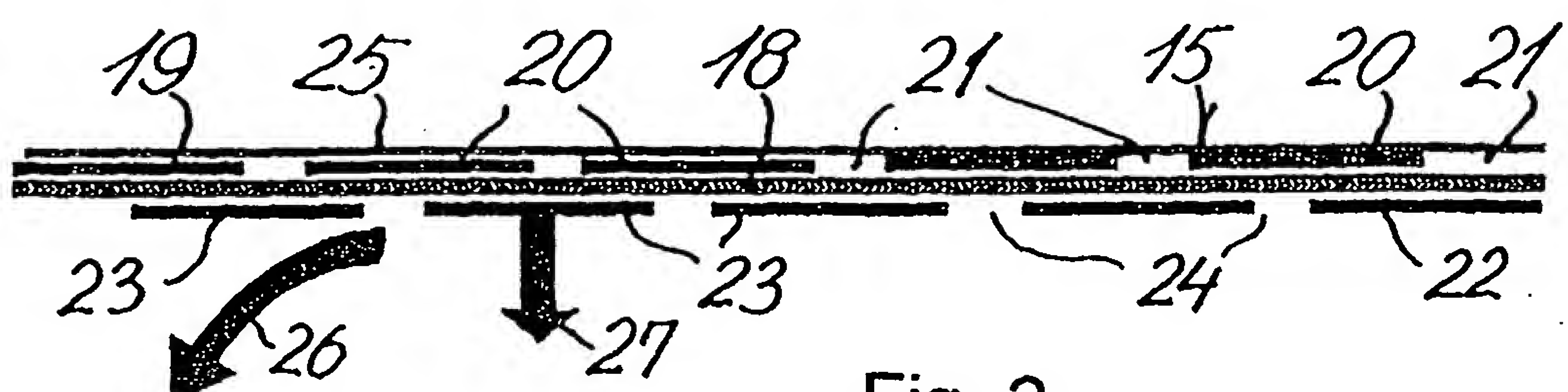

Fig. 2

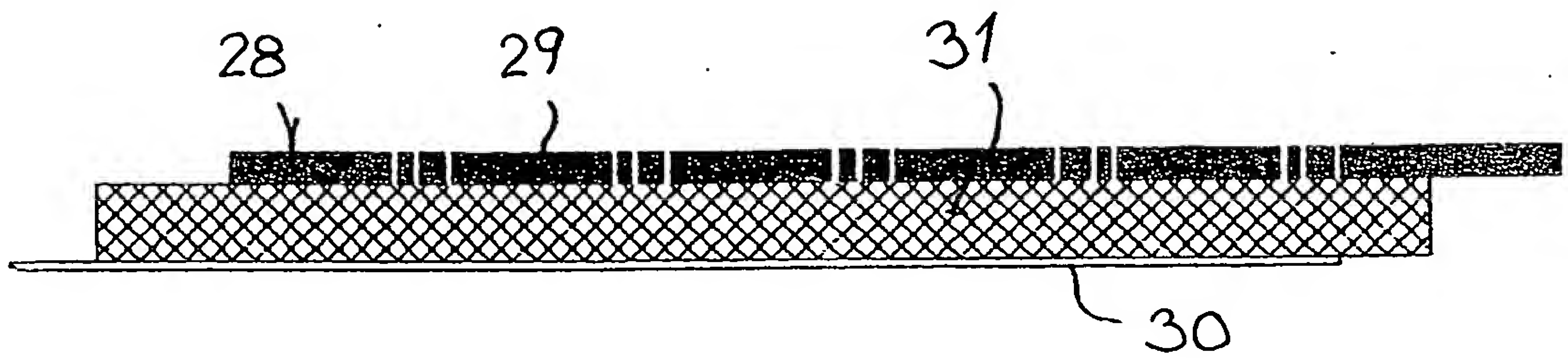

Fig. 3

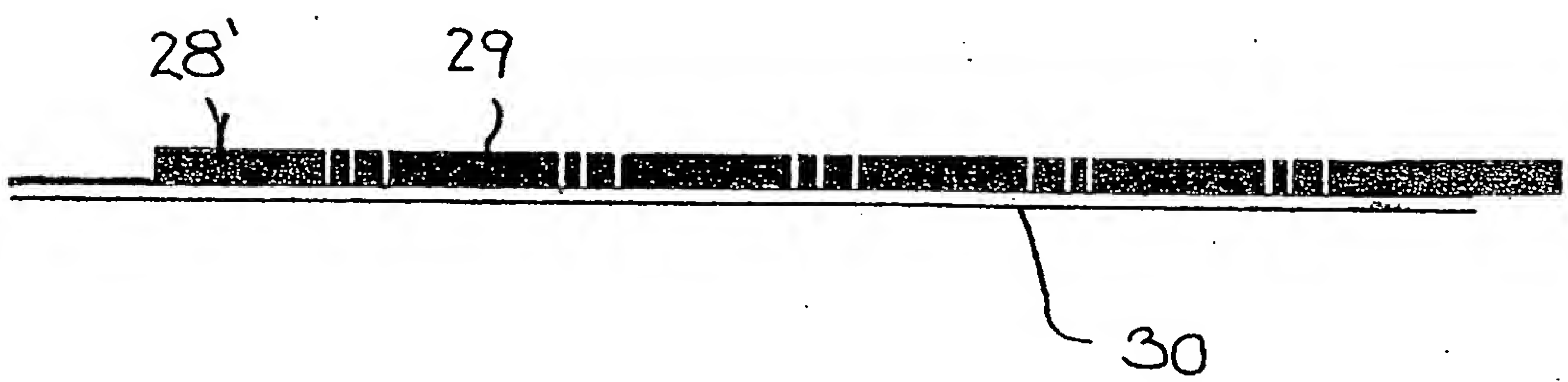

Fig. 4